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SOME OF THE HAZARDS OF AUXILIARY FANS IN COAL MINES

BY

D. HARRINGTON AND R. G. WARNCKE

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SOME OF THE HAZARDS OF AUXILIARY FANS IN COAL MINES[1]

By D. Harrington[2] and R. G. Warncke[3]

INTRODUCTION

Most of those in the Health and Safety Branch, Bureau of Mines, necessarily participate in activities associated with essentially all phases of the mineral industries, including coal and noncoal mines, quarries, smelters, metallurgical plants, and various petroleum operations. One of the strictly war activities of the branch - the Explosives Control Division, which administers the Federal Explosives Act of December 26, 1941 - has functions that require contacts not only with nearly all phases of the mining and allied industries but also with those engaged in scores of other occupations that manufacture, store, use, or possess explosives, or many of the ingredients of explosives.

The field men of the Health and Safety Branch (approximately 300 in number) are occupied full time in health and safety activities and annually make thousands of contacts with people in the mineral industries as well as the plants in which they work. From these they formulate several thousand written reports containing sources of thousands of conclusions and recommendations aimed at reduction of health and safety hazards in these industries. Although such activities have been greatly increased during the war and immediate pre-war periods, they have been in effect to a considerable extent since the Bureau of Mines was created in 1910.

As a result, the Health and Safety Branch has accumulated a vast pool of information concerning health and safety, with especial reference to mining and its allied industries, and has reached rather definite conclusions on the underlying causes of many, if not most, of the failures of those industries to reach full effectiveness in preventing ill health and accidents, as they should have done.

In some instances the conclusions reached by members of the Bureau of Mines who are best-informed, through long service and intimate contacts, in the accumulated health and safety data and experience of the Bureau disagree with the ideas and attitude of many industrial leaders on those particular subjects or procedures.

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One of these subjects, on which there is a rather definite divergence of opinion between many of the leaders of the coal-mining industry in the United States and those in Bureau of Mines health and safety work, is the utilization of auxiliary fans and tubing for ventilation in coal mines. For more than 25 years the Bureau of Mines has opposed this procedure in coal mines; nevertheless, the practice has grown steadily and unquestionably is on the increase. This paper attempts to present some reasons for the Bureau's belief that the use of auxiliary fans and tubing is hazardous in the extreme and that, moreover, it is almost impossible to counteract their hazardous nature.

As discussed in this publication, auxiliary fans are small blower fans, with or without tubing, used to divert part of the air current passing a given point in order to attempt to ventilate some particular place or places in a mine; in other words, it supplements primary ventilation in trying to supply the ventilation needs of individual working places or faces. This paper does not discuss the use of main ventilation fans placed underground or underground booster fans that attempt to take up the entire main air current and force it along. Portable fans with tubing powered by electric motors or compressed air have been used for many years, and to relatively good advantage, in tunnels and metal mines for removing gases from explosives and furnishing air currents in raises, stopes, winzes, and ends of drifts; their use has greatly increased the comfort and safety of the workers, especially those at the working faces. Owing to the conditions and methods of mining in metal mines, especially in development work, they are an integral part of many metal-mine ventilation systems, because metal-mine (or tunnel) workings are seldom driven in more or less parallel pairs or multiples.

For years coal mines have used auxiliary fans with metal tubing to ameliorate conditions similar to those under which they are used in metal mines, namely, in driving single entries or tunnels through rock or rock faults for making connections with other workings. With the advent of the cheaper more flexible canvas or other cloth tubing made available about the end of the First World War, coal-mine operators began to adopt the fan-tubing system in development work, as it permits longer intervals between crosscuts or breakthroughs and results in economies of various kinds. The system was used to some extent to furnish ventilation for longwall mining and later for mechanized mining, which started to become utilized more widely shortly after 1920. Its use was first advocated for nongassy coal mines exclusively because the danger of ignition of gas and the general explosion hazards involved in intermittent ventilation of a place using open lights or electrical equipment was readily recognized. With the advent of mechanized mining and the introduction of new types of electrically operated mining machinery and new systems of face mining, all of which cause rapid advance of the faces, auxiliary fans, usually with tubing, have been installed in nongassy and gassy mines, almost regardless of the hazards involved. At present they are used in all types of mines, not only to aid mechanical mining but also to supplement and cover the deficiencies of poor primary ventilation systems.

MINE SAFETY BOARD DECISION

The rapid increase in the use of blower fans and tubing in coal mines more than 20 years ago raised many questions concerning inherent hazards.

umerous coal-mine explosions and fires were attributed directly or indirectly o them, and many of the installations and methods of use were found to be angerous; this led the Mine Safety Board of the Bureau of Mines to issue the ollowing recommendation approved January 17, 1927, after having given the ubject months of very careful consideration:[4]

> In the interest of safety, the Bureau of Mines recommends that auxiliary fans or blowers should not be used in coal mines as a substitute for methods of regular and continuous coursing of air to every face of the mine.

The discussion following this recommendation states:

> Proper coursing should be obtained by laying out the mine with double or multiple parallel entries, slopes, or rooms, using regularly spaced cut-throughs or crosscuts to provide successive new connections close to the faces being driven and then successively closing them by stoppings or doors in such manner as to leave only the inner cut-through or cross-cut open for air circulation; also suitable splitting of main air currents is essential to proper coursing in practically all mines. In gassy mines, line brattices should be used in each entry, slope, or room, from the last open cross-cut to the respective face. There is great danger in the use of auxiliary fans that fire-damp will be accumulated by recirculation of the air and will be ignited by an electrical spark. Further, the auxiliary fan as commonly used is intermittently operated - that is, operated only when men are in the heading or room - and bodies of fire-damp may collect during times when the auxiliary fan is stopped. Use of electrically driven auxiliary blowers has resulted in a considerable number of explosion disasters.
>
> The only justification for the use of any auxiliary fan in a properly ventilated coal mine is for emergency work, as in driving a cross heading in rock to make a connection with distant workings, and where it is too far to carry air properly by line brattice. In such use the auxiliary fan should be operated continuously 24 hours in the day. It is safer that the fan be driven by compressed air, but if it is electrically driven the motor and switches should be of explosion proof type and an armored power cable employed; especial attention should be given to thorough insulation of wiring; and the vicinity further should be fireproofed to prevent the possibility of starting a mine fire from electrical breakdown or overheating of bearings.

This recommendation, approved 17 years ago, still represents the thought f the Bureau of Mines safety men; the field workers in the Health and Safety ranch engaged in coal-mine investigations or inspections were circularized arly in 1944 as to their present attitude regarding the use of blower fan-ubing ventilation in coal mines, and those who responded were practically naminous in condemning the use of the system in coal mines. Some proponents f the use of blower fans realize the hazards, at least in part, but believe hey they can be used safely if certain regulations and restrictions are

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/ Mine Safety Board, Recommendations of the United States Bureau of Mines on Certain Questions of Safety as of October 1, 1937: Inf. Circ. 6946, 1937, 45 pp. (Decision 4).

imposed on installation and use. As yet no satisfactory regulations or rules have been proposed which remove anything like all of the hazards their use creates; moreover, they are so inherently hazardous that it is not probable that any procedures can be adopted to make them even reasonably safe. Unlike other electrical equipment used at or near the face, which can be made permissible and yet is not supposed to be used in a gassy atmosphere, the blower-fan and tubing system is used to furnish air to the face; to be effective, the blower must be used relatively close to the working face, where the greatest volume of methane is liberated and the ventilation system is weakest. This not only adds another piece of unsafe electrical equipment but its presence and operation make other electrical installations much more hazardous than they might be otherwise.

HAZARDS OF BLOWER-FAN VENTILATION

One of the most dangerous of the numerous hazards of the blower fan-tubing ventilation-procedure is the fact that, unless the equipment is very carefully placed and supervised, the air handled is very likely to be recirculated; in consequence, the explosive gas content is built up if explosive gas is given off, or the carbon dioxide content may be built up and the oxygen decreased, or both of these may occur. In Federal coal-mine inspections numerous auxiliary fans are found to be so placed, or the ventilation so arranged, that air is being recirculated between the faces and the fans. In many instances the fans are in crosscuts, entries, room necks, or other openings through which the return air from the face being ventilated by the fan must pass; recirculation is inevitable. During a certain recent period, 177 mines were inspected where auxiliary fans were being used, and it was found that air was being recirculated noticeably or demonstrably in 91, or man than 50 percent of this group. These inspections covered essentially all sections of the United States, and the above figures give a fair indication of what may be expected in mines where auxiliary fans are used.

In a mine that gives off explosive gas, recirculation of the air from the face can create a hazardous condition even when relatively little is emitted at the face. The air can be recirculated to such an extent that small volumes will be built up to an explosive mixture, which in turn can be ignited by the electrical equipment of the blower, even if no electrically operated machinery or open lights are used at the face.

The intermittent operation of blowers for face ventilation is conducive to the accumulation of gas at the faces when they are idle and there is no air movement in the face region. Many, probably most, auxiliary fans are operated only while men are working and are shut down overnight. Many take current from the trolley line and are subject to stoppage because of power interruptions; some of those are operated only when the trolley line is energized, which ordinarily is only when the locomotives are moving. Few mines should be considered nongassy, as records show many gas explosions in so-called nongassy mines, and if gas is given off by the strata it is certain to accumulate when the blower is idle in any place that depends on a blower fan for ventilation; this necessitates the removal of gas accumulations every time the fan is started. These accumulations may be small in volume, but it is not uncommon for gas to back up in an entry or crosscut to a place outby the fan. Several explosions have been recorded as having occurred in mines when the fan was started, after it had been idle overnight, and an arc from the motor

switch ignited the gas that had accumulated to a point outby the blower
ile it was idle. In these instances use of the blower not only caused the
s to accumulate but the electrical equipment employed in connection with
e blower furnished the source of ignition. In such instances as the above,
operly hung brattice cloth for coursing the air instead of reliance upon
e blower would in all probability have kept the place clear; at least it
uld not have furnished the source of ignition.

Intermittent operation of blowers has been responsible for the movement
gas to adjacent or distant working places or parts of a mine where it was
nited before it was diffused below the explosive limit.

Continuous operation of blower or auxiliary fans might prevent the accumu-
tion that now results from intermittent operation, but continuous operation
troduces an additional hazard because unattended electrical equipment in
mbustible surroundings always presents a definite fire hazard, especially
a coal mine. In most instances the auxiliary fan is attended or inspected
some manner or to some extent during the working shift, and it would probably
unattended during the off-shift periods. The length of time that these fans
y be unattended can be seen readily by a glance at the number of working
ifts a day in bituminous-coal mines, as published for 1942, showing that 5,331
approximately 86 percent of the mines worked only one shift; 632 or approxi-
tely 10 percent worked two shifts; and only 192 or about 3 percent worked
ree shifts. These figures indicate that relatively few fans are likely to
attended throughout the 24-hour period.

The above might prompt the argument that pumps are generally run con-
inuously; however, the cases are not analogous, because operation or non-
eration of the pump has little or no effect on the ventilation or the move-
nt of air and although the unattended electrically operated pump constitutes
fire hazard and occasionally explosive gas accumulates and is ignited by the
mp motor or other electrical accessory, generally the pump surroundings are
mp to wet. Hence, fires or explosions usually are localized, which is by
means likely in the case of the electrically operated blower fans.

The possibility of recirculation of air and intermittent operation are
ubtless among the most outstanding hazards in connection with the use of
ower fans for face ventilation; a still greater hazard, and one generally
erlooked, is neglect of the main ventilating system in many mines where they
e used. Frequently a blower fan is installed as a temporary measure, to be
ed in a place supposedly difficult to ventilate; in many instances it remains
permanent fixture, with the result that the fundamental defects in the main
ntilation that forced temporary use of the blower system remain unremedied.
far too many mines the blower fan is installed to ventilate places that
nnot be reached by natural means, owing to poor planning of the air courses
d ventilation system in general, or more probably to neglect in their mainte-
nce. The ease with which an auxiliary fan can be installed and the temporary
lief apparently achieved frequently lead to installation of a blower fan in
eu of improving or repairing the ventilation system. Moreover, the use of
ower fans allows distances between crosscuts or break-throughs to be increased,

with some immediate economics of various kinds, which ultimately lead to difficulties in ventilating the section involved. In far too many instances the use of blower fans and dependence on them to provide adequate ventilation create a false sense of security; and this, plus the use of nonpermissible equipment in the face regions, combines to permit occurrence of many explosions, some of which are discussed later.

The explosion hazard is always present in the nonpermissible motors and switches and other controls employed in most blower-fan installations, and the hazards of using a blower fan are even greater than with most electrical equipment owing to the possibility of recirculation of air.

A blower fan with tubing nearly always presents a fire hazard; the installations are almost invariably temporary, the wiring and connections are also of a temporary type, the location is usually a dry place with inflammable material in close contact, and often haulage equipment touches or rubs against the fan, the electric wiring or the tubing, or all three. The ease with which a blower is moved from place to place does not promote the care and attention necessary for making safe, efficient wiring and electrical connections; in fact, the entire fan-tubing procedure for providing ventilation at coal-mine face regions is usually slipshod and essentially makeshift - any thing but the type of installation needed to provide adequate ventilation for coal-mine workers and the places in which they work.

STATE REGULATIONS ON AUXILIARY FANS

Certain States take at least some cognizance of the hazards attending use of auxiliary fans supplementing primary ventilation in coal mines and have enacted laws or regulations governing their use.

New Mexico permits electrically driven auxiliary fans or blowers only in a nongassy mine in an emergency and the written consent of the mine inspector. In Colorado small power or blower fans are permitted for face ventilation but are required by law to be set on the intake side of the last crosscut so that recirculation is not allowed.. Pennsylvania bituminous-mining law (1937) permits:

> Booster and/or blower fans in gassy mines to ventilate workings having connection with the air-circuit if they are equipped with a Government-approved flameproof electric motor and if the location of such fans is approved by the district inspector. If an electrically driven auxiliary fan is used in a gassy mine its motor must be placed in intake air.

The Alabama State Mining Department (1938) requires that, in gassy mines, auxiliary fans shall be operated continuously, that the inby end of the fan tubing be maintained within 20 feet of the face, that advancing work be rock-dusted in passages adjacent thereto, that the face region be examined with a flame safety lamp immediately before machinery is started, that gas be removed only in the presence of the mine foreman or other certified official, and that electric machines on the return be stopped and all men be removed from the return from a place if gas is discovered in the place.

PRECAUTIONS BY MINING COMPANIES

Some mining companies that use auxiliary fans also recognize their hazards and have adopted certain precautions to attempt to minimize the dangers. Some companies have printed rules and diagrams to guide their foremen and workmen in the installation and use of fans and tubing. A large anthracite producer requires local colliery officials to apply to the safety engineer for permission to install an auxiliary fan underground. The application must explain why the fan is necessary and why ventilation cannot be accomplished by normal methods of conductiong air to the face; and if granted by the safety engineer, the premission to install the fan must be endorsed by the general manager of the company. Most of these instructions are thorough and complete and would, if followed rigidly and consistently, largely eliminate recirculation of air between the faces and the fan and prevent the movement of gas over the motor and controls.

Few coal-mining companies even approximate adequate precautions in connection with blowers, but the fact that a few do so and in general appear to avoid trouble indicates that, in addition to having adequate knowledge of the dangers and limitations involved with the use of blower fans, the most rigid kind of control of their installations and use must be exercised if they are to be even reasonably safe.

DATA COLLECTED DURING MINE INSPECTIONS

The reports of inspected coal mines in which blower fans are employed show that far too many installatations are made where little or no consideration is given to the hazards involved. This is illustrated by a tabulation based on information collected on the use of tubing and blowers for auxiliary face ventilation in a study of 900 Federal coal-mine inspection reports of bituminous, lignitic, and anthracite mines from December 1941 to June 1943, inclusive, by E. H. Denny and C. H. Seeling, Bureau of Mines, Pittsburgh, Pa.

TABLE 1. - Data on use of auxiliary fans in coal mines
(From a study of 900 reports by Federal coal-mine inspectors)

Federal inspection district	States	No. of inspection reports studied	Mines using auxiliary fans		No. of auxiliary fans used
			Number	Percent	
A	Western Pa. Ohio Northern W. Va. Maryland	381	47	12.3	252
B	Eastern Pa. Anthracite	27	18	66.7	258
C	Southern W. Va. Virginia Eastern Kentucky	197	35	17.8	156

TABLE 1. - Data on use of auxiliary fans in coal mines (Cont'd.)
(From a study of 900 reports by Federal coal-mine inspectors)

Federal inspection district	States	No. of inspection reports studied	Mines using auxiliary fans		No. of auxiliary fans used
			Number	Percent	
D	Tennessee North Carolina Alabama	47	14	29.8	59
E	Indiana Western Kentucky Illinois	176	30	16.9	230
F	Michigan North Dakota	9	3	33.3	7
G	Arkansas Oklahoma	11	4	36.4	18
H	Colorado Utah Washington Wyoming	50	26	52.0	204
Total		900	177	19.7	1,184

Note: This table was taken from a study of 900 Federal coal-mine inspection reports made by E. H. Denny, chief engineer, Coal Mine Inspection Division, and C. H. Seeling, mining engineer, Safety Division of the Bureau of Mines. The period during which the reports were made was December 1941 to June 1943.

Of the 1,184 auxiliary fans in use in coal mines inspected, 5 were operated by compressed-air motors and the remaining 1,179 by electricity. Only 40 of the fans had a type of motor and control rated as permissible by the Bureau of Mines or a motor and control that, when properly maintained, would not ignite gas if operated in an explosive mixture of methane and air; hence, over 95 percent of the auxiliary fans reported in use constitute potentially dangerous sources of ignition if operated in explosive mixtures of gas and air.

Two hundred and thirty-two (232) of the fans were reported as operating continuously, 936 were operated intermittently, and the information on the remaining 16 was of such a nature that this particular feature could not be determined definitely. In some cases the mine management considered the normal ventilation of the working faces by crosscuts and brattices adequate, and the fans and tubing were used chiefly to facilitate the dispersal of smoke and gases developed by blasting; this appears to at least one safe and useful purpose justifying the use of the fan-tubing system in coal mines.

The auxiliary fans in 99 of the 177 mines where they were installed were reported by the inspectors as constituting definite fire hazards which ranged from improper mounting and placement to faulty electrical installations and practices. Many fans were found placed on wooden platforms, often oil-soaked, or in close proximity to coal, timber, combustible waste, or other material.

The installations classed as fire hazards were deficient in one or more following ways: Lack of frame or safety grounding, lack of low-voltage protection, lack of fuses or other protection against overloads or short circuits, motor-lead conductors hung or nailed to ribs or timbers without insulators, poorly insulated open-knife switches, and the hooking of the motor leads over trolley wires or power lines.

In 45 of the 177 mines the fans were said to be used to move accumulations of gas; if gas were to accumulate in a working place dependent upon a blower fan and tubing for ventilation, it is almost a certainty that it would be moved by means of the fans rather than by installation of line brattice; hence, the fan-tubing system probably was used to move gas accumulations in all of the 177 mines, if they had gas accumulations.

As stated previously, recirculation of air was reported in 91 of the 177 mines using auxiliary fans. Special examples of recirculation were noted where several fans were installed in one entry or section to ventilate adjacent or nearby working places, and all fans after the first were intaking return air from the face or faces supposedly ventilated by outby fans. Such conditions become gravely acute when general inadequacy of primary ventilation exists, and unfortunately the presence of auxiliary fans in a coal mine often indicates that such a condition does exist. Moreover, use of the auxiliary fan-tubing system seems to lend itself to indefensibly hazardous practices, such as that described above.

The tubing used with the fans ranged from 6-inch stovepipe to large-diameter flexible fabric tubing; in most of the installations 12-inch flexible tubing was used. The condition in which tubing is maintained has a large influence on the effectiveness and safety of the face ventilation achieved. Some tubing was well-installed, supported on messenger wires, or hung on timbers or along the ribs; in many mines tubing was laid on the mine floor or over and sometimes more or less under gob; with the latter method of installation, pieces of coal, rock, timber, or other objects falling or thrown upon the tubing, or even lying under it, frequently cause constriction at one or more points and reduce or stop the flow of air to the face. Leaks developed at the joints in the tubing, or more frequently at punctures caused by blasting and tears caused by haulage and other equipment, were reported in many installations; in the worst cases the last lengths of tubing were wholly or partly collapsed, and very little air was being delivered at the faces.

In several mines fans were found installed and used without tubing; they were set at or even inby the last crosscut and the discharge orifices aimed toward the working faces. When the fans operated under such conditions, a large percentage of air was being recirculated, and very little benefit was derived at the faces unless they were relatively close to the last crosscut. It was found that in about 75 percent of the installations, the tubing extended to within 20 to 30 feet of the faces, and in the remaining 25 percent the tubing terminated 30 feet to as much as 100 feet from the faces and hence was doing essentially no good.

From the inspector's statements, the face ventilation resulting from the use of auxiliary fans and tubing was found to be "fair" in 20 percent of the faces observed, "good" in about 38 percent, and "poor" in about 42 percent. The quantities of air delivered by fans and tubing were estimated at 500 to 3,000 cubic feet a minute, the latter being a maximum.

Few fans of larger than 4,000 cubic feet rated capacity were reported; the usual capacities were given as 1,800 to 3,600 cubic feet a minute. The quantity of air drops rapidly as the length of the air pipe or tubing increases; and seldom can as much as 50 percent of the rated capacity be delivered, especially if the tubing is much over 100 feet long. This rapid drop depends also on the size of the tubing being used as well as the revolutions per minute of the motor, and after the first few hundred feet of tubing the rate of drop is more rapid. In addition to a reduction caused by friction, natural leakage of the tubing, and other factors the volume of air is reduced further by poorly installed and maintained tubing, leaks, bends, kinks, tears, and constrictions in the tubing.

The conditions under which blower fans are being used, as revealed by the above information, indicate that little progress has been made toward improving the installations, maintenance, or methods of use since they were first generally introduced and used in coal mines about 20 years ago. The same hazards that were obvious then and were viewed with apprehension by many engineers and coal-mining people in those days persist, according to reports studied.

EXPLOSIONS IN MINES WHERE BLOWER FANS WERE USED

Study of the Bureau of Mines records of gas ignitions and explosions in coal mines from 1924 to June 1943 reveals that about 15 percent occurred in mines where blower fans were being used and contributed to some extent to the cause of the explosion. In every year since 1925 at least one coal-mine explosion can be blamed more or less directly on the fan-tubing system. During the fiscal year 1943, 30 explosions were reported, and 10 of these occurred in mines using blower fans. in 1944, up to May, several explosions have been reported in which blower fans have contributed, sometimes directly, to the cause of the explosion.

HOW BLOWER FANS CONTRIBUTE TO THE CAUSE OF EXPLOSIONS

In many of the following 21 short descriptions of explosions in some manner connected with the use of auxiliary fans and tubing, it will be seen that the use of misuse of blower fans for face ventilation was one of the causes of gas accumulation and ignition, although several substandard or dangerous practices may have been jointly responsible. In some instances, blower fans played no part in the gas ignition; nevertheless, their use was accompanied by or was the more or less direct cause of inadequate face ventilation or the indirect result of clogged, insufficient airways or aircourses, insufficient air circulation by the main fan, or short cuts in ventilation to speed production or cut costs without sufficient regard for safety.

These 21 cases are merely a sample of the vast amount of information available concerning the hazards of the fan-tubing system for ventilation in coal mines and of specific explosions caused by the system. Moreover, most of the examples describe relatively recent accidents.

Operating Blower Fans When Ventilating Fan Has Stopped

The following two show the results of operating blower fans when the main ventilating fan is stopped.

Case 1

Two explosions occurred in the same mine within 9 days of each other where electrically operated blower fans were used to augment primary ventilation. In the first explosion 2 men were burned, and the second resulted in the loss of 10 lives.

The mine was opened by two slopes, and all workings were on a pitch. Two surface fans and two underground auxiliary fans ventilated the mine. A small blower fan was used to ventilate a hoist room in a dead end at the top of a slope air course, a larger blower fan ventilated the right side of the mine, and the return air from these fans was exhausted by one of the surface fans.

The first explosion occurred on an idle day while some men were in the mine laying track and building a chute. To build the chute three workmen had to remove the tubing used to conduct air to the dead end where the mine hoist was located. About 3 hours after the tubing was removed the accumulated gas was ignited by an arc from the hoist controller when one of the workmen operated the hoist to lower a car in the slope. The State inspection department had given the mine management permission to use blower fans to connect a manway but had not given permission to extend the use of blower fans for general ventilation purposes.

The second explosion occurred 9 days later. A blower fan was used to supply air to an entry, where a mine hoist had been placed just outby the last crosscut. The fire boss had reported gas 3 or 4 days prior to the explosion, and 2 days previous to the explosion a strong feeder was encountered; about a week before, gas had been detected over the hoist, and a hole was cut in the tubing to remove the accumulation. About 5:15 p.m. the blower fan stopped when the low-voltage release cut off the electric power, and presumably the main fan exhausting from this fan also stopped. The mine foreman started the blower fan in the mine, but neither he nor any of the night shift noticed whether the main fan was operating. The night foreman, who also acted as fire boss, did not make an examination before the men entered the mine and did not enter the mine until about 7:15 p.m. He was rescued near the slope bottom after the explosion, which occurred about 7:25 p.m., before he could make an examination.

The hoist controller was found to be on the second point, and the engineer was found nearby. It is presumed that the surface fan had stopped and the blower fan continued to recirculate the air until the explosive mixture was finally ignited by an arc from the controller when the hoist was started.

Remarks: Both explosions resulted from gross carelessness, but the main contributing factor in each was dependence on blower fans for ventilation. Poor supervision and the use of nonpermissible motors in a gassy mine also contributed to the occurrence, but the underlying cause of the explosions was the lack of adequate means of continuously conducting air to the face, an essential feature of any effective mine-ventilation system but especially required in a mine working in an inclined bed of coal.

Case 2

An explosion killed 61 out of 66 men working in a mine in which the coal bed dipped 25° at the outcrop and flattened to 10° toward the face of the slope. The mine was rated as gassy and was ventilated by an electrically driven booster fan on the intake about half way between the mouth of the mine and the foot of the slope; an electrically driven exhaust fan on the surface was not operating at the time of the explosion. A blower fan with tubing near the face of the slope beyond the last crosscut was used to ventilate a raise being driven off an entry near the face of the slope, which was to connect with a dip being driven from an upper entry. The entry from which this raise was driven was turned off the main slope some distance ahead of the last cross cut, and the blower was located at the intersection of the entry air course and the slope. The fan was driven with a 3-hp., 440-volt, A. C. motor, with the lead wires connected to a three-wire cable a few feet from the motor; the leads were apparently only twisted to the cable and not protected by tape or otherwise.

Evidence gathered in the investigation indicated that the gas was ignited in the vicinity of the blower, and because of its location beyond the last crosscut recirculation was complete, with inevitable upbuilding of the concentration of explosive gas and air.

Three men working on the relay parting about half way up the slope felt the concussion of the explosion and started outside. In passing the booster fan on the slope they noticed that the fan belt had slipped off; owing to the dense smoke, they were unable to put it back again.

Remarks: This explosion occurred when blowers were beginning to be widely used in coal mines and many coal-mining officials thought thay they would solve most ventilation difficulties. In this instance, the blower fan was used to cover poor mining practice and deficiencies of the primary ventilation system by requiring it to perform the almost impossible task of ventilating a raise turned off an entry when the entry had been turned off the main slope ahead of the last crosscut.

In addition, before the explosion the fan belt probably had slipped from the booster fan, located about half way up the main slope; this allowed the blower fan to recirculate the air and gas from the raise until an explosive mixture had accumulated and was ignited by the blower motor or its connections.

This case involves numerous features indicating either gross carelessness or very evident ignorance of the fundamentals of ventilating a coal mine, especially one that gives off gas and is working on a pitch. Scores of explosions, including this particular one, have been caused by driving workings in a pitch (raises, rooms, crosscuts) when the part of the working from which they are driven is beyond the last crosscut through which air is circulating. Circumstances do occur when this procedure is almost unavoidable, but whenever it is adopted utmost cares must be taken or an explosion is almost sure to occur, especially if the strata give off explosive gas and electrically operated equipment is used. Certainly use of the auxiliary fan-tubing system for ventilation when this kind of work is being done is going much farther than tempting providence.

Ignition of Gas Accumulated During Stoppage of Blower

Three explosions caused by ignition of gas, accumulated during stoppage of the blower, by either the motor or the controls of the fan are described in the following:

Case 3

Three men were burned, two of them seriously, in a truck mine owned and operated by four men through a single slope and ventilated by a 12-inch double-inlet blower fan which forced air through 12-inch home-made canvas tubing. A single-inlet blower with a short section of 6-inch metal tubing had been installed in the last corsscut about 40 feet from the face without the knowledge of the State inspector.

The foreman stated that the mine was safe at 7 a.m. when inspected, and both fans were started before the men entered the mine. After working a short time the three men discovered that the fan belt had slipped off the pulley of the small blower. They disconnected the electrical power, then replaced and adjusted the fan belt; the fan was stopped for about 10 minutes, and when one of the men attached the three nips to the power line about 10 feet outby the fan it caused an arc which ignited the gas.

Remarks: The small, single-inlet blower fan in the last crosscut was directly responsible for this ignition, for through its stoppage the gas was allowed to accumulate and back up around the fan, and the source of ignition was furnished by the blower installation.

Case 4

Five men were killed and seven injured by a gas and dust explosion in a mine known to be very gassy and having heavy gas feeders in the places supposed to be ventilated by auxiliary fans.

The face of an entry that was liberating gas freely was ventilated by an electrically operated blower fan installed on the upper rib about 10 feet outby the last open crosscut, with tubing extending close to the face, which was about 60 feet beyond the crosscut. Another similar fan was installed in the last crosscut, with tubing extending close to the face of the back entry about 50 feet inside the crosscut; the switch for this fan was placed on a prop on the low side of the entry just outby the crosscut. The two fans wer stopped for one-half hour or more while the main power line was being splice at an overcast in an upper entry. After the cable was spliced, it was found that the wires that changed the phase had been changed, thus reversing the direction of the motors on the fans in the entry. The foreman, carrying a safety lamp, and the electrician went into the entry to the blower fans, and the electrician started to change the wires on the switch for the blower fan in the crosscut; an arc was formed, igniting the gas which had accumulat and backed up during the time the fans were idle.

Remarks: This explosion might have been averted had the mine foreman inspected for gas while in the entry and cut off the power for the entry at the switch at the main slope before an attempt was made to change the wiring at the fans. The explosion well-illustrates the fallacy of attempting to ventilate entry faces liberating gas with a blower fan; it shows the results of stopping a blower fan for only a short time when the region is really gassy and also illustrates the numerous types of carelessness that seem to be an integral part of auxiliary fan operation; here the mine foreman and the electrician were both guilty of gross carelessness and paid for it with their lives.

Case 5

A fire boss was killed by a gas and dust explosion originating at the switch of an electrically operated blower fan.

A blower fan and ventilation box were used to ventilate a single entry, which had been driven about 180 feet in a mine classed as gassy, and it was not operated when the men were not in the mine - one of the main dangers of auxiliary-fan ventilation.

Presumably the fire boss tested for gas at the blower-fan location and, finding none, started the fan. On making some further investigations, the fire boss found that a fall had occurred in the back entry, causing recirculation of the air; upon discovering that the air was not circulating properly he returned to the fan and was throwing the switch when an arc resulted, igniting the gas accumulated by recirculation. He probably had gone into the air course for about 145 feet, as his mark was found on the ventilation box at that location.

Remarks: This explosion, which fortunately resulted in only one fatality, illustrates several hazards in the use of electrically operated blower fans - intermittent operation; recirculation; use of open-type switches; and dependence on the fan for ventilating a single entry 180 feet ahead of air in a mine known to be gassy.

The foregoing three cases give information on accumulation of explosive gas through stopping of the auxiliary fan and subsequent ignition of the gas-air mixture by the fan motor or the electric power-control devices, such as open-knife switch or the usual nips, etc. These are merely a few typical cases, and it will be noted that an operating or safety official of the mine was directly involved in these three ignitions; this is only a coincidence, as numerous ignitions of a similar nature have occurred when no official was at hand.

Recirculation of Air by Blower Fans

Two explosions definitely attributed to the recirculation of air by blower fans are described below.

Case 6

One man was killed, one seriously injured and one killed in recovery work as the result of an explosion in a mine classed as gassy; ventilation was so defective that over half of the air entering the mine was lost through leaking stoppings and doors on the slope before it was split and entered the active workings on each side of the slope. Electrically operated blower fans are used to ventilate the entries ahead of a longwall face and a single-slope entry.

The explosion occurred in a "spouthole" or single narrow room being driven from one entry off the slope to connect with a lower entry being driven. The hole had advanced approximately 350 feet and was ventilated by a blower fan between the rib and conveyor in a space 28 inches high at the mouth of the room, with little fresh air passing the fan. Twelve-inch tubing was used the first 240 feet and 8-inch tubing the remaining distance. The fan had been operated steadily for at least 15 hours and was recirculating the air. The gas was ignited about 50 feet from the face, after the machine had finished cutting, by the machine helper when he attempted to light a cigarette. The tubing was torn down by the explosion but was replaced during recovery work, and one man lost his life while replacing the tubing as the fan recirculated the air laden with carbon monoxide.

Remarks: The blower fan was the contributing cause of this accident; however, many other ventilation and mining practices were substandard, and the blower fan was expected to cover the deficiencies of the poorly arranged and poorly maintained ventilating system. In this instance there were numerous faulty conditions from the viewpoint of safe operation of a coal mine, and undue confidence was placed in the fan-tubing ventilating system.

It will be noted that several instances cited so far have involved mines working on a pitch; unquestionably the fan-tubing system reaches its maximum weakness and harmfulness in pitching beds, but it is not harmless when used in coal beds that are essentially level.

Case 7

A gas explosion in a gangway off a slope caused the death of 10 men.

The section in which the explosion occurred was cut by a fault and the coal had fallen from the fault over the timbers for about 22 feet leaving an opening where gas accumulated. A 16-foot trough was built to conduct air into this opening, but it failed to keep it clear, so an electrically driven fan using 12-inch tubing was installed and the tubing extended into the trough, and this arrangement kept the place free of gas while the fan was running. The fan was stopped at the end of the day shift and started between 4 to 5 a.m. by the fire boss, who usually found the place full of gas, and generally the place would be cleared after the fan operated 20 to 25 minutes.

On the morning of the explosion a door, placed at the Y of the gangway, which controlled the entire air supply for that part of the mine inby this point, was held open for several minutes while cars were being changed. This short-circuited the air, allowing the full air current to travel into the return airway. With this condition the blower fan recirculated all the air and gas in the pocket. The explosion occurred 2 minutes after the door was closed.

The cause of the explosion was not determined; however, the gas may have been recirculated by the blower while the door was open thereby allowing formation of an explosive mixture which, when the door was closed and ventilation restored, was carried by the air current over some men smoking or over an electric arc; or the mixture may have been ignited by an arc from the blower-fan motor.

Remarks: The above is a good example of attempting to supplement ventilation with blowers and indicates the danger of using them as part of the general ventilation system. In this instance, the blower quickly built up an explosive mixture by recirculating the air; also it would have been necessary to run the blower continuously if it was desired to keep the place clear of gas. A continuous-operation auxiliary fan-tubing system is the exception rather than the rule; this constitutes one of the main hazards of the system, inasmuch as explosive gas is given an excellent opportunity to accumulate while the fan is not operating.

Using Blower Fans for Moving Gas and in Vicinity of Face Region

Some results of using blower fans for moving gas and of having blower fans in the vicinity of the face region are shown in the following three cases:

Case 8

A loader operator was burned severely when gas was ignited as he pushed the switch button to start the conveyor about 7:30 in the morning.

Rooms 1 and 2 had been driven to their limit, and the pillar was being pulled. The conveyor-loading head was located in room 2 and an electrically driven blower fan at room 1, with tubing extending into room 1. A check curtain was hung on the entry between the rooms, supposedly to prevent recirculation of air by the blower. The fire boss started the blower at 4:00 a.m. as he had detected no gas. There was little clearance in room 1 between the tubing and the roof, and it is believed that the blower fan moved accumulated gas into room 2 and over the switch controlling the flow of electricity for the conveyor, which ignited the gas when the switch button was pushed.

Remarks: The blower fan itself did not cause the explosion, but it was largely responsible, as it moved undiluted gas over electrically operated machinery. During the investigation little or no air movement was noticed in this place, and here again is one of the weaknesses of the fan-tubing system; far too frequently this system is expected to do the impossible, namely, to supply air where little or no reasonably pure air is available and probably where there is little or no place for an adequate volume of air to flow to accomplish what is needed in trying to make air conditions in a working place safe.

Case 9

Thirty-four men were killed by a gas and dust explosion in a slope mine, with entries turned off the slope in pairs. Although the air was split by an overcast to ventilate the upper entries, the lower section of the mine where most of the coal was mined was on a continuous current. The mine was rated gassy, and at the time of the explosion it was ventilated by the surface fan operating blowing. The face of the lower entries and slopes were ventilated by electrically operated blower fans with tubing. All coal was loaded mechanically by shaking conveyors or Joy loaders, and shuttle cars were used with the Joy loaders in the section where the explosion occurred.

On the night of the explosion the shotfirer detected gas in the face of a room; the blower fan was removed from the 2d crosscut from the face of the main entries and placed on the gob about 4-1/2 feet from the floor in the last crosscut between the top or main entry and an entry that had been driven up the pitch off the main entry, to remove gas that had accumulated. The 2d crosscut outby the face of the main entries was open, and the air short-circuited through this crosscut with little or none reaching the inside crosscut where the blower had just been placed; while the blower fan was being moved, additional gas accumulated. The explosion occurred after the blower was installed in its new location and started; from evidence gathered during the investigation, the accumulated gas was moved over a loading machine operating just outby the blower fan, where an arc from the loader ignited the gas. However, the gas may have been ignited by the blower-fan motor.

During the investigation and inquest it was learned that the blower fans frequently were used to remove accumulations of gas, always a hazardous operation and one made much more hazardous when electrically operated equipment is utilized.

Remarks: In this instance blower fans were used to force air into places difficult to ventilate, and as long as air was kept moving by the blowers little or no consideration was given to the primary current, which was neglected; this is frequently the picture where the fan-tubing system is used. The blower was placed in a crosscut which received little, if any, of the air from the regular circulating currents of the mine and was used primarily to move an accumulation of gas, the result being that the blower circulated and recirculated air until an explosive mixture was accumulated that needed only a source of ignition, which was present in this case in the electrical equipment being used.

Case 10

A fire boss wearing a carbide lamp was killed by gas explosion when he walked into a body of gas that was being moved from the face by blower fans

The mine was supposed to be nongassy, and at the last crosscut of the main south approximately 3,700 cubic feet of air was found to be moving. Two electrically operated blower fans were used to carry this small quantit of air to the working face of the main south and the side entry; these fans were stopped when workers were not in the mine and were started by the fir boss on his preshift examination.

The fire boss was accustomed to call the surface by telephone between 6:30 and 7:15 a.m., advising whether the day shift should enter the mine. The morning of the explosion he entered the mine late (about 6:20 a.m.) and did not have time to make his examination before it was time to call the surface. He made the customary call to the surface and reported the mine "O.K.", and then started the blower fans, and proceeded to examine the mine Wearing a carbide lamp, he walked into a body of gas being moved back from the face by the fans and eas killed in the resultant explosion.

Remarks: One of the greatest hazards of blower fans is the accumulati of gas while they are idle and the danger of moving this gas in a body ove a source of ignition when the fans are started. Obviously the ventilation of this mine was defective, and blower fans were used in lieu of improving the air courses and using other sound but more expensive methods of providi enough air to the mine workings.

In addition to slipshod ventilation installations and equipment this mine had some definitely unsafe methods of operation; certainly the wearing of an open carbide lamp by a fire boss in his preshift examination of a mine which gives off gas even, if it is misrated as nongassy, is a definite indication of the lack of safety and the inefficiency with which this coal mine was operated.

Moving Gas Over Source of Ignition

Case 11

An ignition of gas in a working driven obliquely up the pitch resulted in nonfatal burns to five men; the place was ventilated by electrically operated auxiliary fans. It was being driven back from a blind crosscut that had been turned off the entry about 150 feet ahead of the last crosscut. Gas had been found at the face of the crosscut by the fire boss, but it was removed and the place reported clear, after which a shaker-conveyor drive and pans were installed in the place being driven up the pitch.

The face of the entry and the blind crosscut were ventilated by an auxiliary exhaust fan installed in the last open crosscut of the entry; the fan was connected with an 18-inch-diameter pipe extending to the face of th entry and a "T" connection of 14-inch pipe extending into the blind

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crosscut. The 14-inch pipe extended to only the low rib of the place going to the rise, where it was found to draw air from the face of that working directly over the conveyor motor. To ventilate the place going up the pitch more effectively, the conveyor crew installed an 8-inch blower fan in the entry a few feet outby the blind crosscut and about 140 feet inby the last crosscut, and extended an 8-inch tubing from the fan through the blind crosscut to within a few feet of the face of the pitch working. The power was off both fans while electrical connections were being made to the conveyor; the fans were operated 5 to 10 minutes before the conveyor was started for trial, and eye witnesses saw an arc on the conveyor wiring ignite the gas.

Remarks: The ignition occurred in the mine of a company that ordinarily attempts to make its mines safe. This episode well-illustrates one of the worst hazards of blower fans and one almost invariably present where explosive gas is given off by the strata, namely, the danger of moving gas over a source of ignition and the accumulation of gas after the blower is idle, if for only a short time.

Failure of Fan-Tubing Systems in Emergencies

Even where auxiliary fan-tubing systems appear to do good work under ordinary conditons, they are likely to fail utterly in an out-of-the-ordinary occasion.

Case 12

Five men were injured in the face of a gangway by a gas explosion; two of them died later.

A chute had been driven to a depth of 20 feet, approximately 40 feet back from the face of the gangway. The two miners working this chute fired five holes, using delay fuses, after which they went home; the explosion occurred some time later.

The gangway and chutes were ventilated by a small, electrically driven fan, supposedly circulating about 4,000 cubic feet of air through tubing to the face of the gangway. The assistant mine foreman found the face of the gangway clear of gas about 10 minutes before the explosion; but the chute in which the shots were fired was blocked with coal, and it was not examined.

The State mine inspector believed that gas was liberated by the shots and the powder ignited the gas, or that a gas feeder was ignited and continued to burn until it ignited an accumulation. The evidence indicated that the explosion occurred about 30 minutes after the shots were fired, hence it appears to be improbable that the explosion was due directly to the shots. Evidence was found that powder burned in one of the holes. The mine inspector recommended that in future air be provided in a chute when it is turned off the gangway.

The chief mine inspector at the time of this occurrence made the following statement:

> The velocity of 4,000 cubic feet of air moving in an open territory would be so low that its sweeping effect upon smoke and dangerous gases does not seem to carry with it that reasonable sense of security.

Remarks: The above statement clearly defines the cause of this explosion as inadequate ventilation and notes that the blower fan failed to provide the needed air current to carry off gases that might be liberated. Many explosions have resulted from using blower fans in essentially the same manner as in this mine, hence the chief mine inspector's statement is applicable to many, if not most, fan-tubing installations, as very few of them deliver anything like as much as 4,000 cubic feet of air a minute.

Electrically Operated Blower Fan

In the following case an electrically operated blower fan was indirectly responsible for an explosion which resulted in eight fatalities.

Case 13

Eight men were killed in an explosion precipitated when a shotfirer was firing shots after the day shift had left the mine. The explosion occurred about 4:30 p.m., during the firing of shots and while the night-shift crew was on the way down the slope reporting for work; all were killed.

The mine was rated gassy, the coal was cut with permissible mining machines and blasted with Cardox, and permissible cap lamps were worn by all underground employees. Line brattice was hung from the last crosscut to the face in the working places; but a blower fan with an open-knife-type switch, located about 50 feet from the face of the slope, was used to ventilate the slope face.

The shotfirer had fired three holes charged with Cardox in the face of the slope; the fourth was charged but not fired. The body of the shotfirer was found near the blower-fan switch, and it is believed that the third shot was fired by touching the ends of the firing cable to the bare part of the switch. The first two shots probably liberated gas, which worked its way up the slope and was ignited by an arc or a spark when the ends of the firing cable were touched to the switch.

Remarks: Several substandard practices were involved in this explosion, but the use of a blower fan in a known gassy mine was probably responsible, directly or indriectly, for the accumulation of gas; and the switch of the fan furnished the source of ignition.

Electrically Operated Fans and Open Lights in Mine Giving Off a "Little" Gas

A very bad combination is a mine known to give off a "little" explosive gas using electrically operated fans and tubing ventilation and workers employing open lights. The inevitable result is exemplified in the following:

Case 14

Four men were killed and one was seriously injured about 7:45 a.m. when a miner wearing a carbide lamp ignited a pocket of gas that had accumulated at the face of an entry. The latter was supposed to be ventilated by an electrically operated blower fan, but the fan had been stopped for 2 or 3 hours before the explosion when a fall in the air course broke the power line to the blower; this allowed the gas to accumulate, and through some further carelessness the workers using open lights were allowed to go to the working face before the fire boss had made a preshift examination.

Remarks: This is a case where the presence of a blower fan evidently gave both the workmen and officials a false sense of security, always extremely hazardous when the fan-tubing system is used in coal mines.

Careless Operation of Fan-Tubing Systems

Some mining companies claim that they are operating fan-tubing systems safely and efficiently, and some individuals appear to be able to handle them more effectively than others; however, the following case indicates the hazard of having some very efficient and some not very efficient handling of fan-tubing systems.

Case 15

Three men were burned because of some careless mining practices. First, the mine was considered nongassy, although it was known to give off explosive gas. Moreover, the mine was ventilated by a continuous current of air. Although the mine was rated nongassy, a fire boss was employed to make preshift examinations; he detected gas in the place where the explosion occurred, started the electrically operated blower fan, and remained until the gas was removed. The explosion occurred about 2:30 p.m. after the broken coal had been loaded out and the place had been cleaned up and a new cut made; the gas was ignited by a coal drill while holes were being drilled preparatory to blasting. This working place was the last one on the air curcuit and evidently was being given insufficient air circulation to keep it safe.

Remarks: The blower fan at this mine responded to the efforts of the fire boss in clearing the face of the gas accumulation found at the preshift examination, but it was incapable of delivering sufficient air to dilute the gas in the place during the working period, especially after it had been freshly cut. The fire boss may have been more than ordinarily efficient in handling the fan-tubing system, but any ventilation system that requires a ventilation expert at every working face to make it effective and to keep it safe is too expensive and too hazardous for present-day coal mining.

Use of Fan-Tubing System When Other Hazards Exist

The auxiliary fan-tubing system has its own hazards, but when other hazards of even worse type are added, the result cannot fail to be bad. In the following case nothing but good fortune prevented two catastrophes.

Case 16

A mine experienced two gas ignitions in less than a month; although no fatalities occurred, several miners were burned on each occasion, and they can charge their singeing to the fan-tubing system of ventilating coal-mine working places.

The panel system is used, three entries being driven and rooms in sets of three or five driven off the air courses; the rooms are driven about 90 feet wide, leaving a 15-foot pillar, and crosscuts are driven at about 200-foot intervals between the rooms. All rooms are ventilated by electrically operated blower fans and 12-inch tubing. The coal bed is considered nongassy but a thin coal seam 6 to 13 inches below emits gas in the form of feeders. Open and closed lights are used by the miners working in the same room or section, in itself a decidedly hazardous practice.

The first ignition occurred in a room that had been driven about 20 feet from the air course; and a blower fan without tubing, located at the room entrance, was used to supply air to the room. Seven men were working in the room, using both open and closed lights, when the machine man (wear-in an open light) ignited a gas feeder, which severely burned two loaders who were wearing closed lights.

The second ignition occurred in a room driven 60 feet off the air course and no crosscuts had been driven. A blower fan had been set in the center of the air course, and the tubing - extended within 25 feet of the face - supplied air to the room. Eight men were at work at the face when the light of one of the workers ignited a gas feeder about 8 feet from the face; the feeder burned a few seconds, and the man who ignited the gas was the only person injured.

Remarks: The ignitions were not serious, but either of them should have warned the operating company that a more positive method of ventilation is absolutely necessary. A tube 12 inches in diameter certainly should not be expected to sweep gases from a room driven 90 feet in width, especially when gas feeders are expected to be encountered. The use of the fan-tubing system is by no means the only hazardous feature in the operation of this mine, but it is one which, if continued, will undoubtedly result in disaster.

Hazardous Gas Accumulations When Fan-Tubing Equipment is Removed or Stopped

One of the numerous hazardous conditions brought about by the fan-tubing system (and one found frequently where the system is used) is that, when active work in a place ventilated by the fan-tubing system ceases and the equipment is removed, the vacated places immediately become dead-ended and have either accumulations of explosive gas or atmospheres deficient of oxygen.

Case 17

Seven men were killed when an accumulation of gas was ignited at the face of a room by an arc from a circuit test lamp which mechanics were using when repairing a motor of a mining machine.

The mine was rated nongassy, and air was deflected into rooms by curtains, but in some rooms air circulation was provided at the face by eletrically operated blower fans with tubing. The fans were at the neck of the rooms, and the tubing was laid on the floor or the gob. The fans were stopped when the rooms were not working.

On the morning of the explosion, the fire boss found gas in the room where the explosion occurred; the adjoining room and the entire section were "dead-lined" or dangered off, but later the place was supposed to have been inspected and the men were allowed to work. All equipment except the blower fan and tubing had been removed from one room the week before, and only a mining machine that was not in operating condition and a face conveyor remained in the other room; both rooms had been driven their limit and were not working. A mechanic was sent into the second of the two rooms to repair the mining-machine motor, and a short time afterward - about 9:30 a.m. - the explosion occurred.

Remarks: The investigators of this explosion considered the blower fan-tubing system a contributing factor to this explosion. If a constant current of air had been deflected into these two rooms by the use of suitable stoppings, deflectors, and line brattices instead of depending on the intermittent use of blowers allowing gas accumulations when the fan was stopped or removed, the accumulation of gas that caused this explosion probably would not have occurred. The proponents of the fan-tubing system will unquestionably believe that assessing blame for this explosion against the system when the explosion occurred after the fan and tubing had been removed is far-fetched. Nevertheless, the fact remains that if the normal procedures of coal-mine ventilation had been used while these rooms were being operated, the places would have continued to be ventilated after active work in these rooms was discontinued.

Hazards of Compressed-Air-Driven Fans

Although the fan-tubing unit reaches its maximum potential hazard when the fan is driven electrically, the electric current is not necessary to the making of the hazard. The following case describes two instances in which explosions occurred due to conditions brought about by the use of compressed-air-driven fans with tubing attached.

Case 18

This mine experienced two gas explosions within 43 days. The first explosion killed two men and injured four, while in the second five men were severely burned: in both instances the places were supposedly ventilated by compressed-air-driven blowers and tubing.

The mine is considered gassy, and the workings are in steeply pitching beds; as is usual with pitching beds, there was much difficulty in keeping the face regions free of accumulations of explosive gas, especially when the workings were being driven up the pitch.

The first explosion followed a shot in loose coal or rock at the end of a slant chute in a steeply pitching vein. The place was supposed to have been ventilated by a compressed-air-driven blower fan and tubing, but it failed to prevent an accumulation of gas; the failure to prevent the gas accumulation was not due to the driving of the fan by compressed air but to the inherent inadequacy of the fan-tubing system to do a good job of sweeping a working face with fresh air.

The second explosion occurred in another section of the mine where two back holes and slant chutes were driven to recover coal left from first and second mining; although direct evidence was not found, smoking is strongly suspected of having caused the ignition.

The accumulation of gas unquestionably was caused through inadequate ventilation because most of the air entered the section through a compressed-air-operated blower, which did not have the capacity to deliver enough air to dilute and carry off the gas being liberated.

Remarks: These two instances aptly illustrate the versatility of the fan-tubing system of so-called ventilation in providing hazards. Here the use of the treacherous electrical current was avoided by using compressed air; but the characteristic ineffectiveness of the system was in evidence in both cases, and gas accumulations (almost inherent where the system is used) occurred. The ignition was furnished by a blasting shot in one case and very probably by smoking in the other.

Deviation from Standard Mining Procedure

Among the worst of the innumerable bad safety features of the fan-tubing system of trying to ventilate coal mine working places are the fantastic deviations from sane, conservative mining procedures that availability of the fan-tubing system permits, as illustrated in case 19.

Case 19.

Two machinemen and a pumper were killed by a gas explosion; the gas had been ignited by arcs from nipping along the trolley line with the machine cable. The mine was rated as nongassy, although some gas had been found and very long chances were taken in using the fan-tubing system.

The explosion occurred in a single entry, which had been driven about 480 feet ahead of the last crosscut; 77 feet back from the face a place had been turned essentially at a right angle and driven about 180 feet, where the parallel entry had been started and driven approximately 60 feet; this made the working place approximately 650 feet ahead of the air. Water conditions were said to be responsible for the driving of the single entry, which was later to be connected to one of the next set of entries to be driven.

This crosscut entry, about 650 feet ahead of circulating air, was ventilated by a blower fan. All investigators agreed that there was a sudden inrush of gas from fissures in the rock overlaying the coal.

Remarks: Little consideration was given to safety here; far too much faith was placed in the blower fan and tubing in attempting to ventilate a place 650 feet ahead of the circulating air and in installing a trolley wire and operating a trolley locomotive essentially that distance beyond the last crosscut. Proponents of the fan-tubing system insist that, even though there may be some hazard in using the system in gassy mines (many, however, think the system is advantageous to use in gassy mines), it is as nearly ideal for nongassy coal mines as for metal mines. Case 19 nicely illustrates the fallacy of this idea; here is a so-called nongassy coal mine taking advantage (undue advantage) of the system and causing the death of three men. Moreover, both in so-called nongassy mines and in definitely gassy mines there appears to be an almost childlike dependence on the system, as is well-illustrated here, where a coal-mine face was being driven at the end of approximately 650 feet of single entry.

Use of Fan-Tubing System to Replace Inefficient Main Ventilating System

Many coal mines, some for one reason and some for another, allow the main ventilation system to "bog down" and try to bolster it locally by use of the fan-tubing system. The fact that the system supplies a little moving air gives local relief by cooling the atmosphere where the air is stagnant, but it often supplies air laden with gas or dust or deficient in oxygen and supplies little or no real ventilation.

Case 20

Four men were killed and two seriously injured in a gas explosion at the face of a gangway which depended upon a blower fan for ventilation.

Two shots had been fired in the face; 15 minutes later another shot was fired, and the explosion followed immediately. The gas may have been ignited by a blown-out shot, a mixed charge of explosives, or a poorly insulated or partly uninsulated shooting wire of a 15-shot blasting unit.

The face of the gangway was at least three crosscuts ahead of its parallel air course, and it was supposedly ventilated by a blower fan. Here again is an example of poor safety practice in driving one of a pair of coal-mine entries three crosscuts ahead of the parallel entry; this is especially hazardous in a mine known to give off explosive gas.

This mine was rated gassy, and main ventilation was supplied by two exhaust fans on the surface and an underground booster fan; small blower fans delivered air to faces of gangways, headings, and chutes.

Remarks: Here is an evident attempt to cover deficiencies in ventilation by use of blower fans; this is one of the main reasons for use of the fan-tubing system, and it really operates to advantage in some working places insofar as it gives a measure of comfort where otherwise the air would be stagnant and hot. However, if the place emits methane or if the strata give off nitrogen or carbon dioxide the use of the blower-fan-tubing system is likely to result unfavorably on health or to cause an explosion. In some instances use of the fan-tubing system where main ventilation is defective due to clogged air courses or other cause has been known so to deplete the oxygen content of air breathed by workers through recirculation of air that an open light or a match would not burn; hence workers were breathing an atmosphere having less than 16 percent oxygen (in which maximum work effort is impossible).

Use of Blower Fans and Tubing Alone in Gassy Mines

The combination of blower fans and tubing to ventilate nongassy mines has numerous hazards from the workers' viewpoint; to rely completely on this system to get air to the working faces of a mine known to be gassy looks like flirting with death. Case 21 is an example of the latter.

Case 21

Four men were killed and one seriously injured by a gas and dust explosion in a place inadequately ventilated by an electrically operated fan and tubing.

The mine was classed as gassy, but the electrical equipment was nonpermissible. Small blowers having a rated capacity of about 1,500 cubic feet of air per minute, driven by the 1-1/2-hp. nonpermissible motors, were used at each working place.

The entry in which the explosion occurred had been closed by the State mine inspector about 3 weeks previously because of inadequate ventilation, although one room was allowed to continue to connect with a room off another entry in an attempt to improve the ventilation. A blower fan was used to ventilate the room in which work was permitted. The State law requires a minimum of 6,000 cubic feet per minute at the last crosscut, and this entry had only 2,000 cubic feet per minute the day before the accident.

The fire boss found no gas on his preshift examination, and the assistant foreman and mine foreman visited the place just before the explosion, which occurred between 9:20 and 9:45 a.m.; neither carried a safety lamp with which to test for explosive gas.

The ignition was attributed to an arc from the mining machine, which was cutting at the face of the room where work was permitted; gas was apparently liberated from the cut, and the small blower-fan unit could not supply enough air to dilute the gas content of the air at the face, where the electrically operated cutting machine was working.

Remarks: Use of the blower fan and dependence on it to furnish ventilation were direct causes of the gas accumulation that entered into this explosion. The officials knew that this section was inadequately ventilated, and the section was worked without improving the main ventilation, reliance being placed (as is done far too frequently) on a blower fan. In this instance faces in a coal mine designated as gassy were being driven with ventilation dependent wholly on small, electrically driven fans and tubing, the rated capacity of the fans being about 1,500 cubic feet per minute. This is a set-up bound sooner or later to result in disaster, and it is very surprising that procedure of this type could operate without almost daily ignitions of gas.

CONCLUSION

The knowledge gained from the use of the auxiliary blower fan-tubing system and the conditions of installation and operation in its present day use in coal mines of the United States show that little if any improvement has been made since it was first introduced in coal mines some 20 years ago.

The hazards that caused the earlier explosions are still present and continue to cause them. Explosions in which blower fans were involved during the past year resulted from hazards similar to those of the earliest explosions; hence, the lessons that should be taught by these explosions appear to have been given little if any consideration when a blower fan is installed.

Rules, regulations, and restrictions for the use of blower fans by a relatively few coal-mining companies have served to a limited degree to afford at least some possibility of safety in the installation and use of the fans, but this is far from typical conditions throughout the industry. It is so difficult to frame adequate regulations for safety in connection with the use of auxiliary blower fans and tubing that it approaches the impossible; the many unforeseen conditions that the use of blower fans create, in addition to the many known hazards, force the conclusion that they are inherently so unsafe that they ought not to be allowed in coal mines, except as an aid under some emergency condition. Owing to numerous known and innumerable unforeseen hazards, it is difficult to justify the use of the blower fan-tubing system in any coal mine, either gassy or nongassy, except under absolute emergency and then only with the consent and approval of the State inspection officials and the higher operating officials of the mining company.